2019

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32ND BLED ECONFERENCE
HUMANIZING TECHNOLOGY FOR A SUSTAINABLE SOCIETY
JUNE 16 – 19, 2019, BLED, SLOVENIA, CONFERENCE PROCEEDINGS
A. Pucihar (ed. et al.)

University of Maribor Press

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Abstract Decisions and business rules are essential Components of an organization. Combined, these components form a basis for securing the implementation of new laws, regulations and internal policies into processes, work instructions and information systems. To ensure proper implementation, business rule types must be taken into account, as the functions per type may be different. The current body of knowledge on decision and business rule management offers some insights into different types of business rules, however, these types are often presented as a secondary focus of a contribution or set in stone without proper evidence supporting these claims. This study therefore aims to explore the different business rule types utilized in the body of knowledge as well as practice. This will form a basis to determine possible overlap and inconsistencies and aid in establishing the functional differences between the defined business rule types. By applying a literature review, semi-structured interviews and secondary data analysis, we observed that the current body of knowledge shows serious diffusion with regards to business rule types, the same holds for practice. Therefore, future research should focus to research these differences in detail with the aim to harmonize the proliferation of business rule types.

Keywords: • Business Rules Management • Business Rules • Types • Comparison • Explorative Analysis •

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DOI https://doi.org/10.18690/978-961-286-280-0.37 ISBN 978-961-286-280-0
Dostopno na: http://press.um.si

1 Introduction

To achieve pre-determined goals, organizations need to make decisions. Decision-making processes depend on the rules that apply within an organization (Kardasis & Loucopoulos, 2004). These rules, often defined as business rules, guide business behavior in accordance with the business policy which is established on the basis of internal or external provided criteria, e.g. (Weiden, Hermans, Schreiber, & van der Zee, 2002; Zoet, Smit, & Leewis, 2015) Morgan (2002) specifically defines a business rule as: "*a statement that defines or constrains some aspect of the business intending to assert business structure or to control the behaviour of the business.*" In this paper, we adhere to this definition. Business rules can best be managed separate, i.e. from processes and data, which is often referred to as Business Rules Management. BRM is defined as: "*a systematic and controlled approach to get a grip on business decisions and business logic to support the elicitation, design specification, verification, validation, deployment, execution, governance, and monitoring of both business decisions and business logic*" (Smit, 2018). Business rules are the cornerstones, together with data, of business logic, which is defined as: "*a collection of business rules, business decision tables, or executable analytic models to make individual business decisions*" (Object Management Group, 2016).

Business rules can originate from many different sources, for example, external organizations. Furthermore, external criteria can be imposed by the government, an example of this is the general data protection regulation law defined by the European Union, which aims to protect the privacy of European citizens. When this law was implemented, all organizations processing data from European citizens needed to change their business rules on handling personal data (European Commission, 2018). Besides this, organizations also add their own business rules which depend, for example, on business strategies or agreements made within the organization. As a result of changing laws, which change at an increasing rate and become increasingly complex (Self-reference, 2018), it is important that business rules are easily adapted, which is the first challenge. To realize this, business rules are often stored in a database separate from other aspects of the system. This enables the separation of concerns i.e. IT developers do not need to concern themselves with business practices while business practitioners have ownership of the business rules, also by the promise to be relieved from programming. Furthermore, it is possible to change the business rules without interfering with the IT department (Von Halle, 2001).

In addition to business rules originating from different sources, a second challenge that organizations face is that more business rules are being created over time. In time, more adjustments and exceptions will arise due to the increased amount of business rules to be used by a business. To create, store and manage these business rules it is useful to give them a classification (Hay, Healy, & Hall, 2000; Madeyski, Śmiałek, Hnatkowska, & Huzar, 2016). In this process, researchers and software developers use their own classification scheme with different rule types, give different names to rules with the same goal or apply different levels of subtypes, often without any design rationale, see for example Wan-Kadir & Loucopoulos (2004) and Bauer (2009). As a result, it is difficult to communicate and make decisions regarding business rules types. Besides making the communication about business rules easier, a common classification scheme will increase the transferability of business rules between and within organizations. This study aims to identify the hypothesized diffusion of business rule types in the current body of knowledge as well as in practice. To do so we defined the following research question: "*What business rule types exist in literature and practice and how do they differ?*"

The remainder of this paper is structured as follows. The next section will provide background and related work regarding business rules, classification schemes and their development, thus providing a clear overview of the current body of knowledge. In the third section, the research method is described, which justifies the type of research that is chosen and how it affects the research techniques utilized. The fourth section will describe the data collection and data analysis, detailing the application of the research techniques. This is followed by the fifth section, which gives an overview of the results, showing the diffusion of the categorization of business rule types in the body of knowledge and practice and a proposal for a standard categorization based on semantic characteristics rather than mere labels. Next, in section six, the conclusions regarding this study are drawn by providing an answer to the research question. The final section will consist of the discussions and recommendations for future research.

2 Background and Related Work

BRM consists of nine capabilities as can be derived from its definition in the previous section. A capability is defined as "*an ability that an organization, person, or system, possesses*." (The Open Group, 2011). How a capability is realized by an organization depends on the situation in that specific organization, i.e., what technology or tooling is available, the maturity of the available technology, the available knowledge, and the available resources. Knowledge regarding business rule types is mainly required as part of the elicitation, design and specification capabilities, however, are also relevant with regards to the verification, validation, deployment, and execution capabilities of BRM.

Contributions regarding business rules types and classifications are published by Von Halle, Ross and the Business Rules Group, which are utilized in many other subsequent contributions to the body of knowledge. The first classification Von Halle coined was published in 1997 in "*The business rule roadmap*" (von Halle, 1997). This classification consisted of definitions, facts, constraints and derivations. A few years later Von Halle published a new classification scheme that contained the rule types: term, fact, mandatory constraint, guideline, action enabler, computation and inference (Von Halle, 2001). In this classification, rules were split into rules constraining information on behalf of the business event (constraints and guidelines), rules enabling other action on behalf of the business event (action enablers) and rules creating new information on behalf of the business event (computations, inferences). In Von Halle's opinion, constraints, computations and inferences deserve the most attention because these guide and restrict behavior in the case of constraints and create knowledge in the case of computations and inferences (Von Halle & Goldberg, 2006, 2009; Von Halle, 2002). This is more important for the business than presenting information. Moreover constraints, computations and inferences are the kind of rules that are often used in commercial rule products and give rise to a debate between database and application professionals (Von Halle, 2001).

Ross wrote several books about business rules and published papers in several magazines. Ross used to split business rules in two types, namely integrity constraints (rules that always yield true) and conditions (rules that may yield either true or false) (Steinke & Nickolette, 2003). In a contribution from 2003, however, Ross added a few more rule types, which resulted in classifications consisting of

facts, terms, rules, constraints, derivations, inferences, timing, sequence and heuristics (Ross, 2003, 2013).

A third line of research is developed by the Business Rule Group. This is a group of experienced practitioners working in public and private sectors dealing with business rules. The goal of the Business Rules Group is to formulate statements and supporting standards in relation to the nature and structure of business rules and the relationship between business rules and business architecture and the way an enterprise is organized (Business Rules Group, n.d.). From the start, the Business Rules Group focused on business rules who could be implemented directly into information technology. In 2000, the Group published a paper in which, amongst others, a classification scheme for business rule types was proposed. This scheme consisted of the following types: structural assertions (divided into terms and facts) action assertions (which can be divided into a condition, an integrity constraint or an authorization) and derivations (divided into a mathematical calculation or an inference) (Hay et al., 2000).

The body of knowledge on BRM and business rule types does not contain, to the knowledge of the authors, a contribution that examines the state of business rule types from a meta-level perspective, also identifying challenges with regards to possible overlap and inconsistencies.

3 Research Method

The goal of this study is to explore the different business rule types utilized in theory and practice and analyse possible overlap and inconsistencies. To select an appropriate research method, one should look at the maturity of the research field (Edmondson & McManus, 2007). The maturity of the business rules management research field with regards to business rule types is nascent and the (scientific) contributions often secondarily focus on business rule types, see also the previous section. In nascent fields, an appropriate focus involves identifying new constructs and establishing relationships between identified constructs. To do so, researchers use explorative qualitative research methods. Therefore, we conduct a qualitative study and, through a multi-method approach comprising a literature review, qualitative semi-structured interviews and secondary data analysis, we search for business rule types and their rationales. A multi-method approach is utilized to create richer and more reliable research results (Mingers,

2001). Given the maturity level of the research domain, this becomes even more important as it allows for a thorough understanding of the phenomenon and its context being researched (Runeson & Höst, 2009).
With regards to the literature review, a descriptive review is conducted in which the focus lies on the empirical as well as the conceptual evidence (Paré, Trudel, Jaana, & Kitsiou, 2015). The scope of a literature review that positions a research question by addressing the theoretical foundations is often characterized by an implicit search process and data extraction process (Kitchenham et al., 2009). However, explicit criteria were applied and are discussed in the next section. The semi-structured interviews were selected to identify the rationale and context of the business rule types in practice, which is harder to grasp when solely utilizing a literature study.

4 Data Collection and Analysis

Data collection for this study was conducted over a four-month period (between November 2018 and February 2019). Data collection for this research paper comprised a combination of three different sources, 1) the body of knowledge on business rules, 2) semi-structured interviews and 3) a set of requirements from seven Dutch governmental organizations regarding decision management and business rules management systems selection. By collecting and analyzing these three data sources we were able to compare and partly triangulate the results. Furthermore, such a combination allows for a richer exploration of the phenomenon studied, by also describing the context in which these business rule types are utilized (Myers, 1997).

Literature review

To ground our literature review with regards to its quality, rigor and transparency, we address the query identification, query combination and operationalization, search strategy and exclusion criteria.

- Query identification; To identify relevant queries, one should look at the scope and goal of the research study. In this case, the research scopes comprises business rule types.
- Query combination and operationalization; Based on the identified queries, a combination scheme with the following terms and operators

was followed: "business rule" OR "business rules" AND "type" OR "types" OR "classification" OR "categorization" OR "category" OR "class".

- Search strategy; Google Scholar was used as main search database due to the fact that it has a higher coverage compared to other search engines or individual database searches (Amara & Landry, 2012; Franceschet, 2010; Harzing & Alakangas, 2016; Wildgaard, 2015).
- Exclusion criteria; Papers or books must be written in English or Dutch for them to be included. Also, identified sources must be available via the internet to be included. No specific date criterion was applied.

Semi-structured Interviews

Data collection for this research is conducted using a semi-structured interview approach. Semi-structured interviews are conversations which are led by a set of predetermined questions/topics. These questions are open-ended and open to interpretation. Utilizing this style of interviews allows the data collection phase to yield better data aiding the identification of business rule types utilized in practice, their rationale and the context in which they were applied (Miles & Gilbert, 2005; Neuman & Robson, 2014).

Eleven business rules management practitioners were interviewed during a four month period (between November 2018 and February 2019). Nine participants were selected from the governmental sector, while two were selected from the commercial (tooling) sector. In total, the participants originated from seven different organizations. The participants had the following roles: two enterprise architects, three business rules analyst, one business rules architect, two business rules consultants, and one business rules management project manager. The average duration of an interview was 45 minutes. The selection of the participants was done based on a combination of snowball sampling (Goodman, 1961) as well as convenience sampling during a Dutch BRM conference for governmental organizations.

During the interviews, an interview protocol was used, to help understand how different organizations deal with the management of business rules. The interview protocol consisted of the following questions: 1) *Which type of business*

rules are used in your organization? 2) *Are the business rules stored in a (separate) database?* 3) *Does your organization employ a classification for business rule(s) (types)?* and 4) *What is this classification based on?* e.g. on a classification from a vendor of business rules engines or on scientific research?

Additionally, the researchers analyzed a set of 1029 requirements to derive business rule types and their rationales. This data was provided by Dutch governmental organizations, which contained information about the requirements with regards to decision management and business rules management systems that must be implemented to support their digital services.

Data analysis

All data, originating from the literature review, semi-structured interviews as well as the secondary data collection, was analysed using thematic coding. To do so, the research team established a coding scheme that was followed during this process, based on meta-data that is useful to compare functionally different business rule types. The following attributes were coded during this process: 1) business rule type label, 2) subtypes, 3) function 4) synonyms, 5) rationale, and 6) examples, according to the ordering/elaboration, dimension and unit coding families defined in Strauss & Corbin (2015). This process was performed by two researchers individually. Then, based on these attributes, an analysis was performed by three researchers. The third researcher conducted sample-wise checks of the coding during this process. The identified business rule types are analyzed using a nominal comparison, due to the explorative nature of this study (Mahoney, 1999). Nominal comparison allowed us to compare and differentiate between business rule types using the six coding attributes described earlier in this paper. The results of this process are presented in the next section.

5 Results

In this section, the results of the literature review, semi-structured interviews and secondary data analysis are presented. When the identified business rule types are described using an example, one uniform example context is utilized. This context concerns the malnutrition check for patients at a hospital, see also (Smit, Zoet, & Berkhout, 2016).

5.1 Business rule types according to literature

As described in the previous two sections, a literature review is conducted to identify business rule types in the body of knowledge.

Table 1: Rule type identification results (body of knowledge)

BR Type	Process rule	Process rule	Process rule	Process rule	Process rule	Derivation rule	Derivation rule	Validation rule	Constraint rule	Constraint rule	Constraint rule	Constraint rule	Constraint rule	Definition rule	Definition rule	Definition rule	Definition rule
BR Subtype	**Trigger rule**	**Precondition rule**	**Postcondition rule**	**Sequence rule**	**Data requirement rule**	**Calculation rule**	**Inference rule**		**Action assertion rule**	**Authorization rule**	**Visibility rule**	**Presentation rule**	**Persistency rule**	**Activity definition rule**	**Actor definition rule**	**Data definition rule**	**Relation definition rule**
Bauer, 2009						X	X	X									
Boyer et al. 2011		X				X	X							O	O	O	O
Date, 2000						X	X		O	O	O	O	O				
Ferreira & Simoes, 2016	X	X	X	X	X		X										
Von Halle, 2001						X	X			X				O	O	O	O
Ghose et al, 2007	O	O	O	O	O				X	X							
Goedertier et al, 2008	X	X	X	X					O	O	O	X	O				
Graham, 2007									X	X				X			
Hay et al., 2000						X	X		O	O	O	O	O				X
Herbst et al., 1994					X	O	O							O	O	O	O
Holmberg et al., 2010		X	X			O	O							O	O	O	X

Jayaweera et al., 2009		X				O	O							O	O	O	O
Kardasis et al., 2004	O	X	O	O	O	O	O							X	X		
Kovacic, 2004	O	O	O	O	O												
Lemmens et al., 2013	O	X	X	O	O	O	O		O	X	O	O	O				
Madeyski et al., 2016		X				X	X		O	X	O	O	O	X	O	X	O
Morgan, 2002						X			X			X					
Group, 2017						O	O		X	X			X				
Park et al., 2004		X		X		O	O		X								
Ross, 2001				X		O	X										
Schlosser et al., 2014		X							O	O	O	O	O	O	O	O	O
Steinke et al., 2003						O	O		O	O	O	O	O	O	O	O	X
Taylor, 2011						O	O	X		X							
Von Halle, 2001		X				X	X		X	O	O	O	O				
Von Halle et al., 2006	X	X		X		X	X		X	O	O	O	O				
Wagner, 2002	X					O	O		X	X							
Wan-Kadir & Loucopoulos, 2004	X	X							X	O	O	O	O				
Wang et al., 2014	O	O	O	O	O									O	O	O	O
Wang, 2017	X	X				O	O			X		X			X		X
Weiden et al., 2002		X	X	X						X		X			X		X
Witt, 2012		X	X	X	X				X	X					X	X	X
Zoet, 2014		X		X		X	X		X	X	O	O	X				
Zur Muehlen et al., 2007	X	X	X	X		O	O		O	O	O	O	O	X			

In Table 1, an overview is provided in which the archetypes are presented accompanied by its source. In total, 36 relevant sources were identified with the search queries described in the previous section. An X in Table 1 denotes the identification of the rule type and subtype, while an O denotes the identification of the business rule type only. For example, when a source states the importance of a definition rule and describes a definition rule, but does not describe what the focus of the definition rule is, i.e. actors, activities or relationships, the definition rule row is denoted with an O. When the focus of a definition rule is explained, the explained subtypes are denoted with an X. The labels of the business rule types described in this paper are derived from the body of knowledge by adhering to the label that was most identified for a given business rule type.

Business rule type descriptions

Based on the results of the literature study, five business rule archetypes were identified, which are 1) Process rules, 2) Derivation rules, 3) Validation rules, 4) Definition rules and 5) Miscellaneous rules. Furthermore, 16 business rule subtypes were identified. The subtypes are described under its corresponding archetype.

Process Rules

A process rule focuses on constraining business processes by defining triggers, activity conditions or sequentiality. Literature analysis revealed five business rule subtypes.

1. Trigger rules causes operation, process, procedure, or rule to be executed when the given condition is true or on the occurrence of a certain event. For example: '*When a patient is registered, the process 'check malnutrition' is must be triggered and started.*'
2. Precondition rules indicate conditions that must be met before a task is performed. For example: '*The malnutrition of a patient may be checked when 1) the patient is not in intensive care, and 2) the patient has a waist width of 120cm or more.*'

3. Postcondition rules indicate conditions that must hold after execution of the task. For example: '*The calculation must yield a malnutrition risk score to be able to determine the malnutrition risk.*'
4. Sequence rules control over the execution of tasks, i.e. the sequencing of tasks within a certain process. For example: '*First the patient has to be checked for direct organ damage after which the BMI is measured. When the BMI is measured, the patient is asked about the food intake pattern.*'
5. Data requirement rules specify the required information flow between tasks. Describe situations in which a task needs information from another task to be able to execute. For example: '*During the BMI measurement activity, the height and weight of the patient as well as the age of the patient must be available.*'

Derivation Rules

A derivation rule focuses on deriving information from collected facts. Literature analysis revealed two subtypes:

1. Calculation rules use a mathematical calculation to derive a new arithmetic value. For example: '*The BMI of the patient is calculated as the weight of the patient in kilograms divided by the height of the patient squared. The patient weight is 52 kilograms and the patient height is 162 centimeters. This results in a BMI index of 19,8.*'
2. Inference rules create new information from existing information. The result is a piece of knowledge used as a new fact. For example: '*When the weight loss of the patient is between 5% and 10%, the weight loss risk points must be set to 1. One of the sub-decisions is 'calculate weight loss risk points' which inferences the amount of risk points based on the weight loss percentage of the patient.*

Validation Rules

A validation rule focuses on checking input value(s) against predetermined values resulting in true or false. No subtypes were identified regarding validation rules. For example: '*The data entered with regards to the weight loss percentage has a maximum of two decimals.*'

Definition Rules

A definition rule focuses on constraining aspects of the business by defining them. Literature analysis revealed four subtypes:

1. Activity definition rules constrain business process elements such as activities by providing a definition. For example: '*During the activity 'determine BMI score' the nurse or physician has to collect the weight, length and age of the patient.*'
2. Actor definition rules constrain actor elements such as roles and attributes by providing a definition. For example: '*The nurse is responsible for the calculation of the patient's BMI score. The physician is responsible for determining the food intake pattern.*'
3. Data definition rules constrain data by defining what comprises the data that represents a fact in the real world. For example: '*BMI is calculated by dividing your weight (in kilograms) by your height (in meters squared).*'
4. Relation definition rules constrain the relationship and its attributes between process elements, actors and/or data by providing a definition. For example: '*Each patient can only have one contact person, which is either a nurse or physician.*'

Miscellaneous Rules

Additionally, five business rule (sub)types were identified that could not be clustered in terms of functionality:

1. Action assertion rules specifies constraints on the results that actions can produce. For example: '*The value that results from the BMI calculation must be between 12 and 60.*
2. Authorization rules specifies who is authorized to perform an action. For example: '*Only nurses with a malnutrition screening certificate level two are authorized to perform malnutrition checks independently, without a physician.*'
3. Visibility rules constrains dynamically the visibility of data within the context of an activity according to the properties of the activity, the data in its state space and the agent that has been assigned to the activity. For example: '*When a physician logs into the malnutrition system, the BMI, weight of*

the patient and other data can be registered. However, when nurses with level one or no certificates login to the system, no patient data can be registered.'

4. Presentation rules define how the system presents itself to the user, how work and tasks are to be organized. For example: '*The user interface for the nurse contains a maximum of three registration fields and one button to submit the data into the system.*'
5. Persistency rules determine how long certain information in an organization should be kept available. For example: '*The patient data regarding malnutrition may be stored until the patient is discharged.*'

Situational factors

Analysis of the body of knowledge also shows that several business rule types actually represent characteristics of other business rule types, and therefore are dependent on the context of the business rules (set). Therefore, these characteristics are reported in this paper as situational factors. The following factors are identified:

- Positive versus negative formulation

It is possible to formulate business rules in a positive or negative manner. A positive formulation focuses on something that is allowed while the remainder is not allowed. An example of this is: '*A nurse may see the BMI score, weight loss percentage and food intake values of a patient.*' Thus, at the same time, this means that the nurse is not allowed to see other information about the patient. A negative formulation focuses on what is disallowed. An example of this is: '*A nurse may not see the patient address details, health insurance details, and job-related details.*'

- Mandatory versus non-mandatory

Business rules that are mandatory need to be followed, and do not allow for alternative approaches. An example of this would be: '*For each patient, it is mandatory to register a BMI score to determine a malnutrition risk score.*' A physician may not override this rule as the BMI score is required to determine a malnutrition risk score of the patient. Non-mandatory rules are guidelines that can be overruled given the circumstances. An example of this would be: '*For each patient,*

it is advised, but not mandatory to register the malnutrition data to determine the malnutrition level of a patient.' Rules that are characterized as mandatory offer the mitigation of risk, however, are less flexible in execution when, for example, exceptions arise.

- Enforceable versus non-enforceable

Each of the identified business rule types, with the exception of definition rules, can be enforceable or non-enforceable. For enforceable rules it is possible to compel people to follow this rule, this applies for example to the rule: '*A physician and a nurse must enter his/her personal code to add, manage or monitor patient malnutrition data*.' Contrary to enforceable rules, some rules are hard or impossible to enforce, which are referred to as non-enforceable rules. An example of such a rule would be: '*A patient should always be greeted with a handshake*.'

- Monitorable versus non-monitorable

The monitorable factor indicates whether it is possible to monitor violations of rules. An example of a non-monitorable rule is: '*The patient is required to tell the nurse how much he or she has eaten during the last five days*.' It is impossible for the nurse to check whether the patient is telling the truth. A rule that is monitorable, however, is for example: '*The patient needs to gain 300 grams per day in weight during the first week*.'

Synonyms

In addition to the situational factors, the literature analysis also revealed multiple business rule types described that are exactly equal in terms of function. Therefore, these are labelled as synonyms for the business rule types presented in Table 1. Due to space constraints, this paper does not present all synonyms identified. However, to ground our claim, two examples of synonyms are provided. The first example comprises the business rule type *Derivation rule*, which is also referred to as an 1) *Informative rule*, 2) *Assumption rule* or 3) *Deductive rule*. The second example focuses on the situational factor, which often seems to be described as a business rule type, non-mandatory business rules. A non-mandatory rule is also referred to as a 1) *Behavioral rule*, 2) *Suggested rule*, 3) *Guideline rule*, or 4) *Advice rule*. In total, 30 synonyms were identified in literature.

5.2 Business rule types according to practice

As described in the previous two sections, several semi-structured interviews were conducted as well as 1029 functional requirements were analysed to identify business rule types applied in practice.

Analysis of semi-structured interview data

In total, eleven business rule management practitioners were interviewed to derive business rule types utilized in practice. In Table 2, these business rule types are described.

Table 2: Rule type identification results (semi-structured interviews)

Business rule type	Function	Subtype	Function
Process flow/rule	To guide sequentiality.	**Duration**	A rule to determine how long a business event may take.
		Action rule	A rule that expresses a set of conditions followed by the actions to take if the conditions are true.
		Technical rule	Represent specific loops in the action part of rules.
		Structural rule	A rule that constraints the relationships between metamodel elements.
		Action enable	Tests a condition and upon finding it true will initiate a business event, message or other activity.
Derivation/ decision rule	A rule that derives information from collected facts.	**Inference**	Create new information using existing information using logic.
		Calculation rule/computation	Create new information using existing information based on mathematical computation.
Validation rule	A rule that checks the input value(s) against predetermined values resulting in true or false.		

Miscellaneous rule types	N.A.	**Stimulus and response rule**	Constrains behavior by specifying when and if conditions must be true in order to trigger certain behavior.
		Operation constraint rule	Specify those conditions that must hold true before and after an operation to ensure that the operations perform correctly.
		Structure constraint rule	Specify policies or conditions about classes, objects and their relationship that should not be violated.

Analysis of secondary data

In addition to the semi-structured interviews conducted, a set of 1029 requirements with regards to BRM systems were analyzed. This resulted in the identification of eleven business rule types, see Table 3.

Table 3: Rule type identification results (secondary data)

Business rule type	**Function**	**Subtype**	**Function**
Process rule	A rule that focuses on procedure and sequence in order to guide a process.	Conversion rule	A rule that converts information to, e.g., a boolean value.
		Technical rule	A rule defined in the technical language itself (e.g. Java, C++).
Derivation rule/Decision rule	A rule that derives information from collected facts.	Inference rule	A rule that creates new information from existing information.
		Calculation rule	A rule that uses a mathematical calculation to derive a new arithmetic value.
Validation rule	A rule that checks the input value(s) against predetermined values resulting in true or false.		
Actor rule	A rule that defines the actor and its characteristics such as linked activities or authorization.		

Miscellaneous rule types	N.A.	Stimulus and response rule	A rule to define cause and effect relationships.
		Structure constraint rule	A rule that constraints the relationships between metamodel elements.

Situational factors

Consistent with the situational factors regarding business rule types found in the body of knowledge, situational factors were also identified during the analysis of business rule types in practice. The following three situational factors are identified:

- Mandatory versus guidelines

This factor is also identified in the body of knowledge and is utilized the same way in practice.

- Encourage, prevent or allow behaviour

In the governmental sector, business rules are often drafted to encourage behaviour, prevent behaviour or allow behaviour depending on the circumstances. Business rules are therefore classified as either encouraging, prevention or allow actions.

- External versus internal sources

The participated organizations all utilize internal and external sources to ground their business rules. External sources refer to law and regulations defined by regulating parties. Internal sources are defined on top of the external sources, to exert more or other control over the business, e.g. policies. For each defined rule, it is registered what the origin of the source is.

5.3 Literature versus practice comparison

For clarity, the identified business rule types from theory and practice are compared in figure 1.

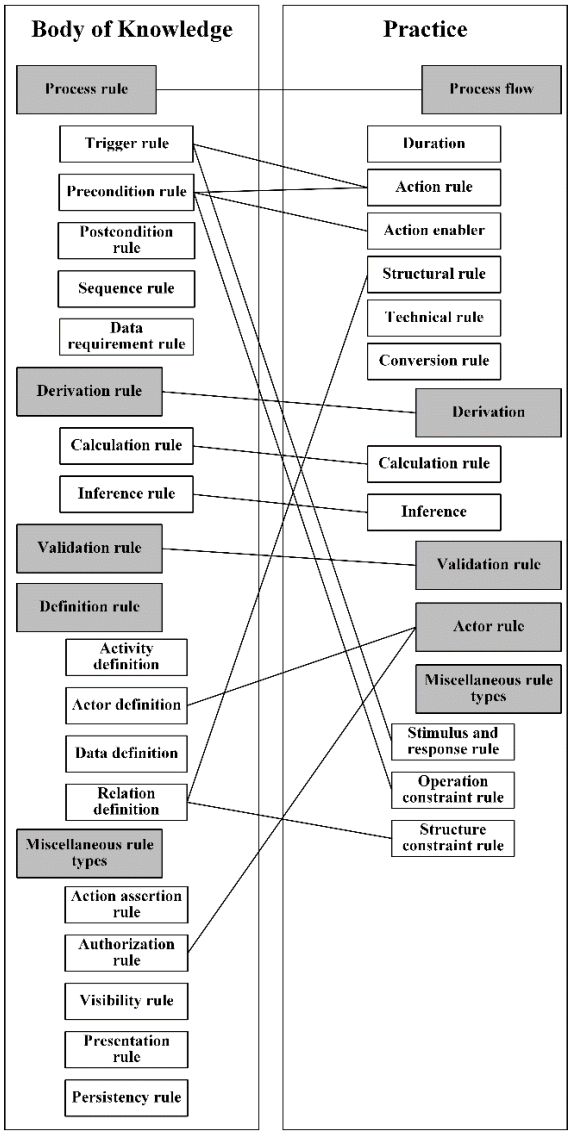

Figure 1: Mapping of business rule types (body of knowledge vs. practice)

6 Conclusions

The goal of this research was to answer the following research question: "*What business rule types exist in literature and practice and how do they differ?*" To do so, a multi-method approach was applied comprising the collection and analysis of the body of knowledge, semi-structured interviews data and secondary data regarding business rule types. This research shows that in the current body of knowledge, many business rule types are defined. However, analysis also shows that the current body of knowledge occasionally lacks proper functional argumentation and descriptions as well as proper examples of rule types. Rule types seem to be a secondary objective in such contributions. Additionally, the body of knowledge also shows large diffusion with regards to rule type labeling, which makes comparison and transferability much harder, as rule types are presented as new but are essentially synonyms of existing rule types. In total, 16 business rule subtypes were identified in the body of knowledge, divided over four rule type categories. All (sub)types identified differ in functionality and are accompanied with an example. After the body of knowledge was analyzed, data was collected from practice on business rule types. Similar to the body of knowledge, business rule types are applied which are functionally the same, but labelled differently. Analysis shows that the practitioners and their organizations involved in this research seem to utilize some contributions from the body knowledge, however, they mostly define business rule types themselves. Lastly, a comparison of business rule types utilized in theory and practice is presented in Figure 1. A close look shows that the body of knowledge and practice do utilize the same rules in a functional perspective to a large extent, however, also appear to use different labels. Concluding, we answered our research question by providing types of business rules utilized in theory and practice, which created an opportunity to analyse the differences.

7 Discussion and Future Research

This research has several limitations. First, when referring to practice, we refer to the Dutch governmental organizations that were included in this research. We do not claim that these results are generalizable towards the whole Dutch governmental sector or even larger than that. Given the fact that this research has an explorative focus, a small sample size is sufficient, however, future studies should incorporate larger sample sizes applying both qualitative and quantitative

research methods to increase generalizability. Additionally, industries other than the government should be included in future research. The combination of semi-structured interviews and secondary data analysis provides a novel view of how business rule types are defined and utilized, however, we cannot fully claim that the organizations included do not utilize all business rule types identified in the body of knowledge, as these organizations utilize many different information systems and experts that work in a silo setting. Future research that focuses on establishing a uniform overview of business rule types in the body of knowledge with the help of a Structured Literature Review could help in forming a key contribution that can be utilized by practitioners. Such a contribution could also reduce the proliferation of business rule types applied in practice, possibly increasing the ease of collaborating regarding business rule identification and formulation between organizations. Lastly, this study examined how the business rule types differ within and between literature and practice, however, an interesting venue for future research would be to identify the rationale 'the why' of these differences.

Acknowledgments

We would like to thank the Dutch governmental BRM conference committee (in Dutch: expertisegroep BRM) for the opportunity to interview participants during the conference as well as the participants themselves for their expertise and valuable time investment.

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